MARS EXPLORATION ROVER LANDING SITE BOULDER FIELDS. R. D. Schroeder[1] and M. P. Golombek[2], [1]California State University Bakersfield, Department of Geology, 9001 Stockdale Highway, Bakersfield, CA 93311-1099, rschroed@cs.csubak.edu, [2]Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109.

Introduction and Methods: As an aid in constraining the rock size-frequency distributions at the Mars Exploration Rover (MER) landing sites, Mars Orbiter Camera (MOC) images of all potential MER landing sites were systematically searched for boulder fields. Low-Sun angle MOC images can be used to identify boulders larger than 1.5 m diameter, which can be used to determine the shape of the rock size-frequency distributions. These distributions can be compared with the rock size-frequency distributions measured at the Viking and Mars Pathfinder landing sites to better quantify potentially hazardous rocks at the MER landing sites.

The Viking and Mars Pathfinder landing sites show rock size-frequency distributions that largely follow an exponential when expressed in cumulative fractional area covered by rocks of a given diameter or larger versus diameter plots [1]. Similar rock distributions were also measured at a wide variety of rocky locations on the Earth. These distributions form a family of non-crossing curves that flatten out at small rock diameter at a total rock abundance of 5-40% [1].

Low-Sun angle MOC images show boulders as distinctive light-dark pixel pairs [2] (Figure 1).

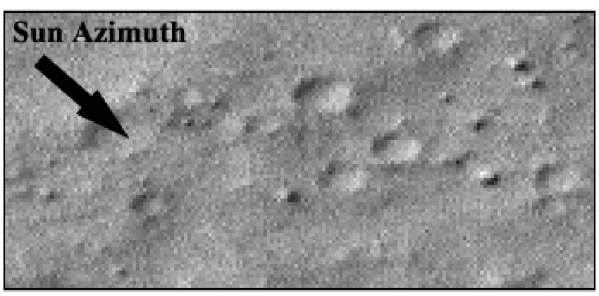

Figure 1. Boulders in Sample 2 area at 1.5 m / pixel resolution in MOC image E1801498.

The diameter is simply the number of pixels across the boulder, measured perpendicular to the Sun azimuth (along the line between the light and dark pixels). This measurement is scaled for the image resolution, emission angle, and angle of the perpendicular to the Sun azimuth relative to the pixel grid. In practice, boulders down to one pixel diameter could be measured as a light and dark pixel pair. Measured boulder diameter is probably within ±1 pixel.

Results: We systematically searched 143 MOC images within and nearby the final 4 landing ellipses [3]. We found 14 boulder fields within the ellipses, half of which are in Gusev (Table 1). We also found 13 boulder fields nearby, but outside the ellipses, again with 7 of these in Gusev. All boulder fields are associated with craters. The craters are not fresh (no fresh ejecta or pristine bowl shapes), however, so the boulder fields are likely the remains of crater ejecta on a modified surface that has been eroded or partially covered.

The Gusev landing ellipse contains the most boulder fields, followed by Isidis, and then Elysium. The current 34 MOC images that cover the Meridiani landing ellipse contain no boulder fields (Table 1). In general, the boulder fields found at Isidis are not as pronounced as those found in the Gusev site. There may be one possible boulder field in the Elysium ellipse.

Table 1: Number of boulder fields in MOC images of the landing sites.

MER Landing Sites	Ellipse Boulder Fields	Total MOCs Observed	Total Boulder Fields
Gusev	7	48	14
Isidis	6	46	10
Elysium	1	15	3
Meridiani	0	34	

Gusev Landing Site: Twenty-four of 48 MOC images in Gusev contained a total of 14 different boulder fields, seven of which are in the current landing ellipse. In two cases, boulder fields were independently identified in two separate images. The largest boulder field in the Gusev landing ellipse was independently identified in 5 separate images (Figure 2). This boulder field covers a circular area roughly 4 km in diameter. Boulder field measurements were made from the largest boulder field using MOC image E1801498 with a resolution of 1.5 m/pixel.

Two sample areas Quad 1 (Q1) and Sample 2 (S2) were measured. Q1 represents the average distribution of this boulder field, while S2 exhibits the area with the highest concentration of boulders (Figure 2). The Q1 sample area is 3,241,728 m^2 and has 0.34% of its surface covered by boulders >2 m in diameter (Figure 3). The S2 area covering 268,254 m^2 has the maximum boulder coverage in any of the landing sites. S2 has 1.41% of its surface covered by boulders >2 m in diameter (Figure 3). As for the other boulder fields measured in MOC images on Mars [2], the cumulative

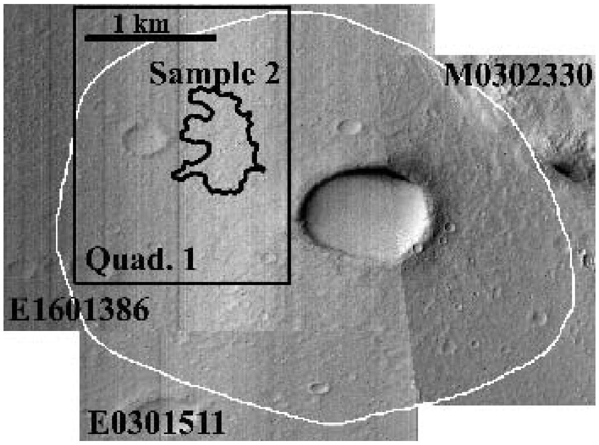

Figure 2. Locations of S2 and Q1 in largest boulder field in Gusev ellipse. The image incidence angle of 44.09°, and emission angle of 17.92° were taken into consideration when boulder diameter measurements were made.

fractional area versus diameter plot is parallel to the model distributions [1] but at larger diameter. Also as for the other boulder fields measured on Mars [2], it is not clear what happens to these distributions at smaller diameter. The fall off in cumulative fractional area at diameters below 6 m is probably a resolution affect in which fewer and fewer boulders are recognized as the boulder diameter approaches the pixel size (analogous to crater counts). Nevertheless, the curves cannot continue parallel to the model curves at smaller diameters, because the surfaces would exceed 100% rock coverage.

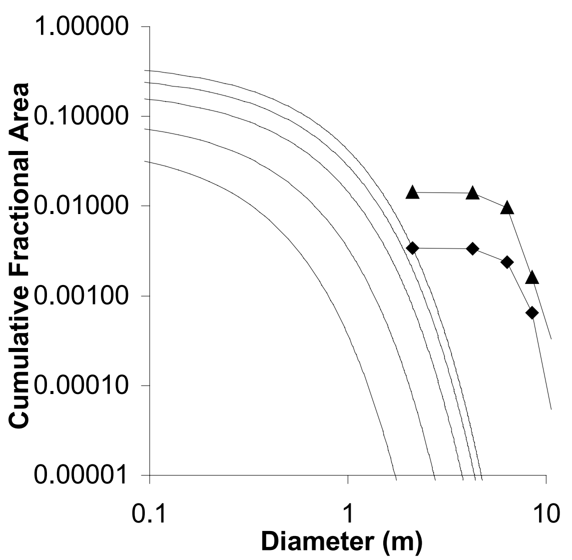

Figure 3. Cumulative fractional area versus diameter plots of boulder fields Q1 (diamond), S2 (triangle), and model rock distributions [1] for 5%, 10%, 20%, 30% and 40% rock coverage (from lowest to highest).

The cumulative number of rocks/m^2 >2 m diameter for Q1 is 0.000148 and for S2, 0.000649 (Figure 4). As for the cumulative fractional area distributions, the cumulative number distribution for Q1 and S2 are parallel to model rock distributions (derived by numerically integrating the cumulative fractional area curves shown in Figure 3), but at a larger diameter. The drop off in number of rocks below 6 m is probably the resolution fall off. It is also unclear what happens to the distributions at smaller diameters.

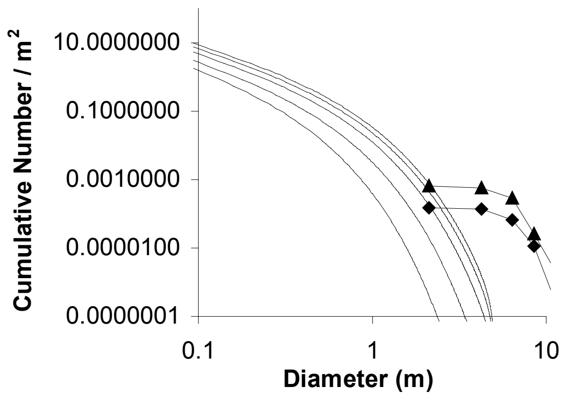

Figure 4. Cumulative number of rocks/m2 versus diameter for boulders measured in Q1 (diamond), S2 (triangle), and model rock distributions for 5%, 10%, 20%, 30% and 40% rock coverage (from lowest to highest) derived by numerically integrating the model distributions shown in Figure 3.

Given that area S2 has the highest concentration of boulders observed in any of the landing ellipses, this distribution represents a maximum. The maximum area covered by boulders larger than 2 m in diameter is only 1.4%, so the probability of impacting a boulder in this boulder field in the Gusev landing ellipse is about 1% in one bounce [4]. Given that only a small fraction of the ellipse is covered by boulder fields, the probability of actually impacting a boulder is much smaller. As Gusev has the most boulder fields, the probability of impacting boulders at the other ellipses is even lower.

References: [1] Golombek M. and Rapp D. (1997) *JGR, 102,* 4117–4129. [2] Golombek M. (2001) LPS XXXII, Abstract #1116. [3] Golombek M. et al. (2002) *LPS XXXIII* Abstract #1245. Golombek M. et al. (2003) *LPS XXXIIII* Abstract #1754. [4] Golombek M. et al. (2003) *LPS XXXIIII* Abstract #1778.